July 29, 1952 L. C. VAN ATTA 2,605,419

WAVE GUIDE FEED FOR ILLUMINATING PARABOLIC REFLECTORS

Filed Oct. 11, 1945

FIG. 1

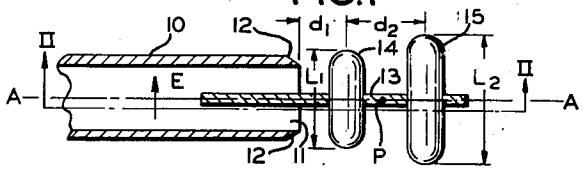


FIG. 2

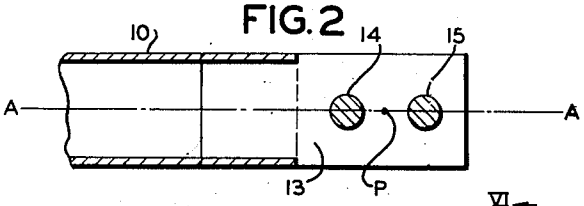


FIG. 3

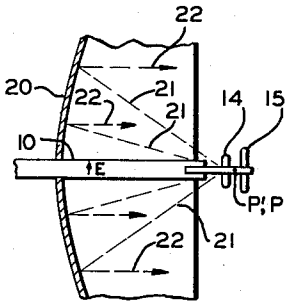


FIG. 4

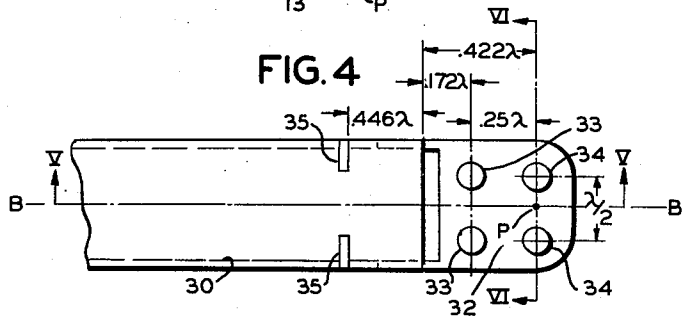


FIG. 6

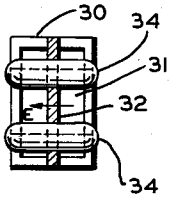


FIG. 5

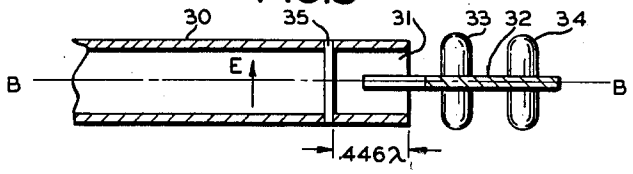
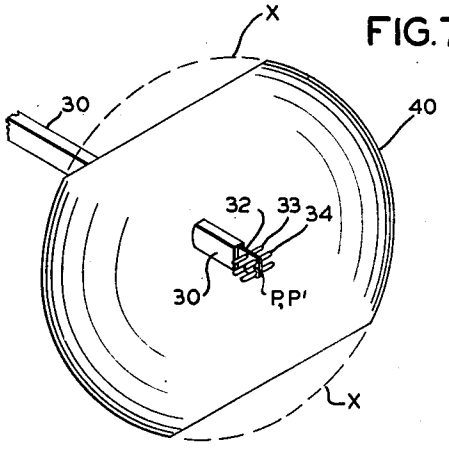


FIG. 7



INVENTOR
LESTER CLARE VAN ATTA

BY
Ralph L. Chappell

ATTORNEY

Patented July 29, 1952 2,605,419

UNITED STATES PATENT OFFICE

2,605,419

WAVE GUIDE FEED FOR ILLUMINATING PARABOLIC REFLECTORS

Lester C. Van Atta, Winchester, Mass., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application October 11, 1945, Serial No. 621,834

19 Claims. (Cl. 250—33.65)

1

My present invention relates in general to directive radio antennas, and in particular to means for illuminating a parabolic reflector with energy from an open-ended wave guide positioned at the focal point thereof.

In radio apparatus employing frequencies sufficiently high to permit the use of wave guides for transmission lines, and parabolic reflectors as elements in the antenna systems thereof, it is convenient to construct a directive antenna of a parabolic reflector or paraboloid having an open-ended wave guide transmission line mounted in and projecting through a hole at the center and along the axis of such reflector, up to but not quite touching the focal point thereof. Energy emerging from the open end of the wave guide may then be reflected to the paraboloid by a small disc mounted on a suitable frame near the mouth of the wave guide. The reflecting disc and the mouth of the wave guide are usually positioned to include between them the aforementioned focal point.

A chief difficulty with this type of illuminating source for a parabolic reflector is that in effect a ring source of illumination is obtained from the reflecting disc rather than a point source, and therefore, the energy illuminating the paraboloid cannot be made to come effectively from the focal point thereof. Consequently, the beam reflected from the paraboloid will be distorted and contain a relatively large number of side lobes and the gain of the main lobe will be smaller than is desirable.

It is therefore an object of my invention to provide illuminating means for a parabolic reflector that will produce a point source of radiation which may be adjusted substantially to coincide with the focal point of the parabolic reflector. Broadly, this object is realized by providing an open-ended wave guide for illuminating the reflector, the open end of the wave guide being located near the focal point of the reflector. A metallic web lying in a plane perpendicular to the direction of the E vectors of the wave in the wave guide is mounted in the open end of the wave guide, and extends outwardly therefrom a short distance to include the said focal point. An array of rod shaped antennas is mounted perpendicularly in this web and is arranged to provide a virtual point source of illumination. This point source is made to coincide with the focal point of the reflector. As will be appreciated from the discussion hereinafter to follow, any conventional array of antennas may be mounted in the web of my invention.

2

It is a further object of my invention to provide such illuminating means that will be self-supporting mechanically and require no external struts or framework.

It is a still further object of my invention to provide such illuminating means that will be able to be mounted in the open end of a wave guide without interfering with or attenuating the energy passing therethrough.

These and other objects and features of my present invention will become apparent upon a careful consideration of the following detailed description when taken together with the accompanying drawing, the figures of which illustrate typical embodiments of my invention.

In the drawing:

Fig. 1 is a side sectional view of an antenna in accordance with my invention;

Fig. 2 is a cross section along the line II—II of Fig. 1;

Fig. 3 illustrates the antenna of Figs. 1 and 2 incorporated in a system having a parabolic reflector, the reflector being partly broken away;

Fig. 4 is a top view of another antenna in accordance with my invention;

Fig. 5 is a cross section along the line V—V of Fig. 4;

Fig. 6 is a cross section along the line VI—VI of Fig. 4; and

Fig. 7 illustrates the antenna of Figs. 4 to 6 inclusive in combination with a truncated parabolic reflector.

In Figs. 1 and 2, a rectangular wave guide 10, having an open end 11 with the outer surrounding edges 12 of the top and bottom walls beveled toward said open end 11, has a flat web 13 mounted in said open end and extending outwardly therefrom along the longitudinal axis A—A of the wave guide 10. The web 13 may be mounted in the open end 11 of the wave guide 10 in any convenient manner, as for example, by slotting the narrow walls of the said wave guide and inserting the web 13 in the slots and soldering it in place. The web 13 may extend a short distance into the wave guide 10. The wave guide 10 is adapted to carry electric waves in a mode having the electric vectors E directed transversely to the axis A—A, and the web 13 lies in a plane which is substantially perpendicular to the direction of said electric vectors E. First and second rod-shaped antenna elements 14 and 15 which each may be in the neighborhood of one-half wave length long are mounted substantially perpendicularly in and through the web 13 along an extension of the axis A—A. The antenna elements 14 and 15 may have different

lengths, in the present example the one 15 furthest removed from the opening 11 being the longer. Thus the longer element 15 may act in the maner of parasitic reflector with respect to the shorter element 14, or the shorter 14 as a parasitic director for the longer 15, depending upon the choice of length L_1 and L_2 thereof with respect to the length of said electric waves. In the present example, the two antenna elements 14 and 15 are arranged so that together they appear to effect the interchange of energy between the wave guide 10 and space at a point P located on the line between their centers. Thus, when the system of Figs. 1 and 2 is radiating, the point P seems to be a point source of radiation.

The shorter antenna element 14 of length L_1 is spaced outwardly from the open end 11 a distance d_1 while the longer element 15 of length L_2 is spaced still further outwardly from the shorter element 14 a distance d_2. As is apparent from known antenna practice, these distances and lengths d_1, d_2, L_1 and L_2 may be varied experimentally to provide a desired pattern. A specific set of dimensions which I have found suitable for use in illuminating a parabolic reflector are as follows:

The length L_1 of the shorter element 14 should be approximately 0.44λ;
The length L_2 of the longer element 15 should be approximately 0.50λ;
The spacing d_1 may vary from the limit of 0.12λ to 0.16λ; and
The spacing d_2 may vary between the limits 0.13λ to 0.20λ;

where λ is the free space wave length of the wave being carried in the wave guide 10. These dimensions, however, are typical of a specific case only, and not the only dimensions that may be used with this antenna of my invention.

In operation, energy in the wave guide 10 having electric vectors E may proceed from the wave guide 10 into space through the open end 11. The antenna element 15 being of a length equal to a half wave length will be resonant to these waves, and will start to radiate. The shorter antenna element 14 acts as a parasitic director for the longer antenna element 15, so that the two elements together radiate in a direction which is back over the outer wall of the wave guide 10, acting at the same time as a point source centered at the point P. This process is reversed upon reception, inasmuch as an antenna will work equally well in both directions.

In Fig. 3, the apparatus illustrated in Figs. 1 and 2 is shown mounted in and through an opening in a parabolic reflector 20, the wave guide 10 being coaxial with the axis of the reflector 20 and extending toward but not reaching the focal point P' of that reflector. The elements 14 and 15 are so positioned that the point P contained between them is substantially coincident with the focal point P' of the reflector 20. Thus, upon transmission, rays 21 emanating from the mouth of the wave guide 10 and the array therein will be reflected from the reflector 20 as a collimated beam of rays 22. Likewise, in reverse, a collimated beam of energy or waves reaching the reflector 20 will be brought to the focal point P' and into the wave guide 10. Thus the antenna array of my invention may be used for illuminating a parabolic reflector to provide a narrow beam of energy having high gain in the major lobe and simultaneously having low or small minor lobes.

In Figs. 4 to 6 inclusive, there is illustrated another embodiment of my invention having a wave guide 30 with an open end 31 and a web 32 therein similar to the web 13 of the embodiment of Figs. 1 and 2. The web 32 supports two groups of rod-shaped antenna elements, each group comprising first and second elements 33 and 34 respectively. Each group is arranged in a line which is parallel to the axis B—B of the wave guide 30. The groups are spaced apart laterally substantially a half wave length and preferably have the axis B—B equidistantly contained between them. Matching curtains 35 are provided in conventional fashion for matching out the susceptance introduced by the array of antennas 33 and 34 and the web 32. Again, as in the apparatus of Figs. 1 and 2, the array comprising the antenna elements 33 and 34 will aid in the interchange of energy between the wave guide 30 and free space as if this energy were coming from or entering the wave guide at a point P contained among the elements 33 and 34 respectively. Likewise, as in the apparatus of Figs. 1 and 2, the wave guide 30 is adapted to carry electric waves in which the electric vector E is directed transversely to the axis B—B and the web 32 lies in a plane substantially perpendicular to the direction of these electric vectors E.

A specific set of dimensions for the apparatus illustrated in Figs. 4 to 6 inclusive is as follows:

The distance from each first radiator 33 to the open end 31 of the wave guide 30 is 0.172λ;
The distance between a first antenna element 33 and its associated second element 34 is 0.25λ;
The lateral distance between groups of antenna elements is $\frac{1}{2}\lambda$.

A suitable distance between the matching curtain 35 and the opening 31 is 0.446λ. These dimensions will provide an array in the open end of the wave guide 30 which is suitable for illuminating a parabolic reflector as will hereinafter be explained. However, it is to be understood that these distances and dimensions are exemplary only and not the only distances which are suitable for use with this antenna of my invention.

In operation, the apparatus of Figs. 4 to 6 inclusive is similar to the apparatus of Figs. 1 and 2, in that, energy proceeding from the wave guide 30 will excite the antenna elements 33 and 34 into radiation since they are of substantially resonant lengths. The first elements 33 may act as parasitic directors for the respective second elements 34 as hereinabove set forth, thereby causing the radiation to be directed back over the outer walls of the wave guide 30. Since there are two groups of antenna elements 33 and 34 side by side and spaced a half wave length apart in accordance with conventional antenna array theories, the beam will have narrow directivity in the plane of the web 32 with respect to the directivity in a plant perpendicular to that web. This is usuable in illuminating a truncated parabolic reflector as will be now explained.

In Fig. 7, the antenna of Figs. 4 to 6 inclusive is mounted in and through a truncated parabolic reflector 40 having opposite portions X removed, as by cutting along substantially parallel chords. The wave guide 30 is so positioned in the reflector 40 that the E vectors of the radiation carried thereby will be directed horizontally. Again as before, the wave guide 30 is coaxial with the reflector 40 and extends up to but does not quite reach the focal P' thereof. The array comprising antennas 33 and 34 is so positioned with re-

spect to the parabolic reflector **40** that its point of radiation P is substantially coincident with the focal point P' of the reflector **40**.

Operation of the antenna of Fig. 7 is similar to the operation of the antenna of Fig. 3 except that the beam will be somewhat fan shaped, being broader in the vertical direction than in the horizontal direction due to the fact that the parabolic reflector is truncated at the top and bottom and therefore does not have the resolving power or the beam forming power that it has in a horizontal plane. The provision of two groups of radiators **33** and **34**, side by side, provides sufficient directivity properly to illuminate the cut paraboloid **40** in the narrow dimension.

Since certain changes may be made in the above described invention and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. It is further intended that this invention is not to be limited except insofar as is necessitated by the prior art and the spirit of the appended claims.

What is claimed is:

1. A radio antenna comprising, an open ended wave guide adapted to carry electric waves in a mode having its electric vectors directed transversely to the longitudinal axis thereof, a substantially flat metallic web mounted in the open end of said wave guide and projecting outwardly therefrom in a plane substantially perpendicular to the direction of said electric vectors, and an array of rod-shaped antenna elements substantially resonant to said waves mounted at various points in said web substantially perpendicularly to the plane thereof.

2. A radio antenna comprising, an open ended rectangular wave guide adapted to carry electric waves in a mode having its electric vectors directed transversely to the longitudinal axis thereof, a substantially flat metallic web mounted in the open end of said wave guide and projecting outwardly therefrom in a plane substantially perpendicular to the direction of said electric vectors, and an array of antenna elements comprising first and second rod-shaped antenna elements substantially resonant to said waves mounted substantially perpendicularly in said web in spaced relation along a projection of said axis, one of said elements being shorter than the other, said array providing substantially a point at which said waves are interchanged between said wave guide and space.

3. Apparatus in accordance with claim 2 in which said first and second antenna elements are respectively substantially 0.44λ and 0.50λ long, said first element is spaced outwardly a distance equal to a value contained substantially between the limits 0.12λ to 0.16λ from the open end of said wave guide, and said second element is spaced farther outwardly a distance equal to a value contained substantially between the limits 0.13λ to 0.20λ from said first element, where λ is the free space length of said electric waves.

4. A radio antenna comprising, an open ended rectangular wave guide adapted to carry electric waves in a mode having its electric vectors directed transversely to the longitudinal axis thereof, a substantially flat metallic web mounted in the open end of said wave guide and projecting outwardly therefrom in a plane substantially perpendicular to the direction of said electric vectors, and an array of antenna elements substantially resonant to said waves comprising first and second laterally adjacent linear groups of antennas, each group comprising first and second rod-shaped antenna elements mounted substantially perpendicularly in said web in spaced relation along a line parallel to said axis, said first elements being of different length than said second elements, said array providing substantially a point at which said waves are interchanged between said wave guide and space.

5. Apparatus in accordance with claim 4 in which said first elements are each spaced outwardly from said open end a distance substantially equal to 0.172 λ, said second elements are each spaced further outwardly from the associated first element a distance substantially equal to 0.25 λ, and said groups are spaced apart laterally a distance substantially equal to 0.50 λ, with the projection of said axis contained equidistantly between them, where λ is the free space length of said waves.

6. A radio antenna comprising, an open ended wave guide adapted to carry electric waves in a mode having its electric vectors directed transversely to the longitudinal axis thereof, a parabolic reflector having a focal point, said wave guide being mounted in and through said reflector coaxially therewith, the open end of said wave guide extending toward but not reaching said focal point, a substantially flat metallic web mounted in said open end and projecting outwardly therefrom in a plane substantially perpendicular to the direction of said electric vectors, and an array of rod-shaped antenna elements substantially resonant to said waves mounted at various points in said web substantially perpendicularly to the plane thereof, said array providing a point substantially coincident with said focal point at which said waves are interchanged between said wave guide and space.

7. Apparatus in accordance with claim 2 in which a parabolic reflector is mounted coaxially with the longitudinal axis of said wave guide and with its focus substantially coinciding with said point.

8. Apparatus in accordance with claim 4 in which a parabolic reflector is mounted coaxially with the longitudinal axis of said wave guide and with its focus substantially coinciding with said point.

9. A radio antenna comprising, an open ended wave guide, a conductive rod resonant at the frequency of the high frequency wave carried by said wave guide, and means to support said rod a predetermined distance from the open end of said wave guide.

10. A radio antenna comprising, an open ended wave guide, a dipole resonant at the frequency of the high frequency wave carried by said wave guide, and means to support said dipole a predetermined distance from the open end of said wave guide.

11. A radio antenna comprising, an open ended wave guide, an array having first and second conductive rods substantially resonant to the high frequency wave carried by said wave guide, and means to support said rods in a predetermined spaced relation to the open end of said wave guide to provide a desired radiation pattern.

12. A radio antenna comprising, an open ended wave guide, an array having a plurality of conductive rods substantially resonant to the high frequency wave carried by said wave guide, and means to support said rods in a predetermined

spaced relationship to the open end of said wave guide to provide a desired radiation pattern.

13. A radio antenna comprising, an open ended wave guide, a substantially flat support mounted in the open end of said wave guide and projecting outwardly therefrom in a plane substantially perpendicular to the electric field of the wave carried by said wave guide, and an array of antenna elements comprising first and second rod-shaped elements substantially resonant to said wave mounted perpendicularly in said support in spaced relation along a projection of the longitudinal axis of said wave guide, one of said elements being shorter than the other, said array providing a spherical wave with its origin substantially a point.

14. Apparatus in accordance with claim 13 in which a parabolic reflector is mounted coaxially with said longitudinal axis of said wave guide and with its focus substantially coinciding with said point.

15. A wave guide feed for illuminating a directive high frequency antenna of the barabolic reflector type comprising an open ended wave guide positioned coaxially with the axis of said reflector, said wave guide extending toward but terminating before reaching the focal point of said reflector, a substantially flat support rigidly mounted at the open end of said wave guide in a plane passing through said focal point and perpendicular to the electric field of the energizing wave being carried by said wave guide, and an array of parasitic antennas comprising first and second substantially resonant rod shaped elements mounted substantially perpendicularly in said support and disposed in a pattern to radiate toward said reflector a spherical wave whose center of origin is at said focal point.

16. A wave guide feed for illuminating a directive high frequency antenna of the truncated parabola reflector type comprising an open ended wave guide positioned coaxially with the axis of said reflector, said wave guide extending toward but terminating before reaching the focal point of said reflector, a substantially flat support rigidly mounted at the open end of said wave guide in a plane passing through said focal point and perpendicular to the electric field of the energizing wave carried by said wave guide, and an array of antenna elements substantially resonant to said wave comprising first and second laterally adjacent linear groups of antennas, each group comprising first and second rod-shaped antenna elements mounted substantially perpendicularly in said support in spaced relation along a line parallel to said axis, said first elements being of different length than said second elements, said array radiating a beam with a directional pattern to feed a truncated parabola, said beam having a point of radiation coinciding with said focus point.

17. Radio transmitting antenna apparatus comprising a paraboloidal reflector defining a directive axis and a focal point, ultra high frequency energy supplying means extending through said reflector substantially along said axis to said focal point for radiating energy from the region of said focal point toward said reflector to produce energy transmission in a directive pattern, and conductive means supported by said energy supplying means and positioned intermediate said focal point and said reflector at a point separate from said axis for modifying said directive transmission pattern.

18. A directive radio antenna comprising a paraboloidal reflector defining a directive axis and a focal point, an open ended wave guide extending through said reflector substantially along said axis toward said focal point, and a plurality of resonant dipoles arrayed in a predetermined spaced relationship to the open end of said wave guide for directing energy emerging from said wave guide toward said reflector.

19. A directive radio antenna comprising a paraboloidal reflector defining a directive axis and a focal point, an open ended wave guide extended through said reflector substantially along said axis toward said focal point, a supporting web mounted in the open end of said wave guide and projecting outwardly therefrom in a plane substantially perpendicular to the electric field of the wave carried by said wave guide, and a plurality of dipoles substantially resonant at the frequency of the wave carried by said wave guide, said dipoles being arrayed in a predetermined spaced relationship in said supporting web for directing energy emerging from said wave guide toward said reflector.

LESTER C. VAN ATTA.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,745,342	Yagi	Jan. 28, 1930
2,370,053	Lindenbald	Feb. 20, 1945
2,380,519	Green	July 31, 1945
2,407,057	Carter	Sept. 3, 1946
2,409,183	Beck	Oct. 15, 1946
2,413,558	Goddard	Dec. 31, 1946
2,429,640	Mieher et al.	Oct. 28, 1947
2,453,751	Kinnier	Nov. 16, 1948
2,454,805	Kandoian	Nov. 30, 1948